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GRAIN YIELD, DRY MATTER REMOBILIZATION AND CHLOROPHYLL CONTENT IN MAIZE (*ZEA MAYS* L.) AS INFLUENCED BY NITROGEN AND WATER DEFICIT

MAHTA HAGHJOO AND ABDOLLAH BAHRANI*

Department of Agriculture, Ramhormoz Branch, Islamic Azad University, Ramhormoz, Iran

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Abstract

Out of 20, 40, 60 and 80 per cent moisture depletion 20% showed significantly higher grain yields, biological yield, chlorophyll a, b than the others. However, the highest contribution of stem and leaf dry matter remobilization in grain yield were obtained in 80% moisture depletion and 300 kg N/ha and the lowest one was found in the 20% moisture depletion and 150 kg N/ha. Nitrogen application increased all traits, however there were no significant difference between 250 and 300 kg N/ha.

Introduction

In the Mediterranean climate region of Iran, water and nitrogen are the factors that limit the grain yield of maize (*Zea mays* L.). Therefore, to see how restricted irrigation and different nitrogen fertilizer affect dry matter remobilization, grain yield, chlorophyll and cartenoid content of corn, an experiment was conducted in a semi-arid area in Fars, Iran. Maize is the third most important cereal crop in the world after wheat and rice which is frequently subject to environmental stress, particularly periods of long-term water shortage (Li 2007 and Mohammadi *et al.* 2012).

Drought stress is one of the most important environmental stresses affecting agricultural productivity worldwide and can result in considerable yield reductions (Lauer 2003). Drought limits plant growth and productivity more than any other environmental factor in the arid and semi-arid area. Water stress was found to reduce leaf area; photosynthesis, leaf chlorophyll contents and consequently grain yield (Islam *et al.* 2012). The yield decrease under drought stress at the reproductive stage was greater than that at the vegetative and grain filling stages (Fatemi *et al.* 2006 and Khalili *et al.* 2010)

Most maize in developing countries is produced under low N conditions because of low N status of tropical soils, low N use efficiency in drought-prone environments, high price ratios between fertilizer and grain, limited availability of fertilizer, and low purchasing power of farmers. It was suggested that nitrogen affects osmotic regulation, cell wall elasticity, carbohydrate metabolism and synthesis of drought-induced signal substances in roots (Amanullah *et al.* 2009 and Karimpour *et al.* 2013)

In maize as well as in other cereals, the supply of assimilates to grain during grain filling originates from current assimilation transferred directly to kernels and from the remobilization of assimilates stored temporarily in vegetative plant parts before anthesis (Ercoli *et al.* 2008). This source diminishes during grain filling due to leaf senescence, which is often fastened by stress conditions, while the carbon demand of the growing grain remains high during most of the grain-filling period (He *et al.* 2004).

*Author for correspondence: <abahrani75@yahoo.com>.

The objectives of this study were to assess the effect of a water deficit on the remobilization dry matter stored in stem and leaf plant tissues and its contribution to grain yield during the grain-filling period and the interaction of water stress and nitrogen in relation to chlorophyll a, b, cartenoied content.

Materials and Methods

A filed experiment with a hybrid maize (*Zea mays* L.) variety SC-260 was conducted in research field of the Islamic Azad University of Shiraz, Iran in 2012. The climate is semi-arid with 1350 meters altitude from sea level. The investigation was arranged as split-plot experiment based on the randomized complete block design with four replications. Main-plots were assigned to four irrigation regimes (MD1:20%, MD2:40%, MD3:60% and MD4:80% moisture depletion) and sub-plot were also four nitrogen levels; 150, 200, 250 and 300 kg N/ha in forms of urea. Seeds were sown on 7 July, 2012 with a four rows planting machine, and were 6 m long and 4.5 m wide, with 6 rows 0.75 m apart.

One third of nitrogen was given at the time of land preparation and remaining was applied as top dressing at ZGS-23 and ZGS-60. Irrigation treatments were applied 30 days after planting. Drip irrigation system was used in the study. The soil water content measurements were done one day before irrigation until harvest in four replications for all treatments by gravimetric sampling in 0 - 0.30 m as follows:

$$V = \frac{(FC - \theta m) \times Pb \times Droot \times A}{E\,i}$$

where; V = Volume of irrigation water per cubic meter, FC = Per cent moisture content at field capacity, $\theta\,m$ = Per cent moisture content before irrigation, Pb = Soil bulk density grams per cubic centimeter, A = Irrigated area per square meter, D_{root} = Depth of root development according to meters, $E\,i$ = Irrigation efficiency.

At silking and grain physiological maturity, leaf and stem were harvested for contribution of dry matter remobilization. All plant parts were oven dried at 65°C to constant weight for dry weight determination.

Contribution of dry matter remobilized to grain (%) = (DM remobilization / grain yield) × 100

Chlorophyll a, b and carotenoid of the plant were measured at the fully expanded ear leaves at tasseling stage. Three leaves were collected per plant from five plants per treatment. Leaves were frozen in liquid N_2, stored at –80°C for no longer than 10 days, then freeze dried. Freeze-dried tissue (1 g) sample was grinded along with 40 ml acetone 80% (v/v). The resulted green liquid was transferred through Whatman paper No. 2. Eventually, the final liquid volume using acetone 80% was made up to 100 ml. Light densities of chlorophyll extract were measured using spectrophotometer at 645, 663 and 452 nm wave lengths. Chlorophyll a, b as mg/g leaf fresh weight was calculated according to Dhopte and Manuel, (2002):

Mg chlorophyll a = [12.7(D663) – 2.69 (D645)] × V/1000 w

Mg chlorophyll b = [22.9(D645) – 4.68(D663)] × V/1000 w

where, D, light densities of chlorophyll extract, V, final volume of chlorophyll extract in acetone 80% and w is leaf fresh weight as gram.

Grain yield values were adjusted to 15.5% moisture content.

Data were analyzed by analyses of variance using the general linear model (GLM) procedure provided by SAS (2004). When significant differences were found (p = 0.05), the DMRT was carried out.

Results and Discussion

Irrigation treatments significantly affected the grain yield ($p < 0.05$) (Table 1). Grain yield varied from 6533 to 8877.5 kg/ha among the treatments (Fig. 1). The highest average grain yield was observed in MD1 treatment as 8877.5 kg/ha and the lowest yield was found in MD4 (80% FC) treatment as 6533 kg/ha. The highest and lowest grains yield in consumption of 250 kg N/ha was 8877.5 kg/ha and in 150 Kg N/ha was 6533 kg/ha (Fig. 2). Deficit irrigation treatments at the highest nitrogen fertilizer treatment increased grain yield to 17% (Table 2). Corn grain yields were reported to vary from 3.26 t/ha in dry-treatment to 8.51 t/ha for the full irrigation for sprinkler irrigated corn by Boz (2001) in full irrigation treatment for surface irrigated corn in the first and second year by Kirda *et al.* (2005) and for full irrigation for drip-irrigated corn in the same experimental site by Bozkurt *et al.* (2006).

Table 1. Analysis of variance for moisture depletion and nitrogen fertilizer.

Sources of variation	Grain yield (kg/ha)	Biologic yield (kg/ha)	PLDMR † (%)	PSDMR‡ (%)	Chl. a (mg/g/Fw)	Chl. b (mg/g/Fw)	Carotenoid (mg/g/Fw)
Moisture depletion (MD)	*	*	*	*	*	*	ns
Nitrogen fertilizer (N)	*	*	*	*	*	*	ns
MD × N	*	*	*	*	*	*	**
CV (%)	7.09	7.66	9.02	8.87	15.87	10.24	13.68

†= Partitioning of leaf dry matter remobilization, ‡ = Partitioning of stem dry matter remobilization.

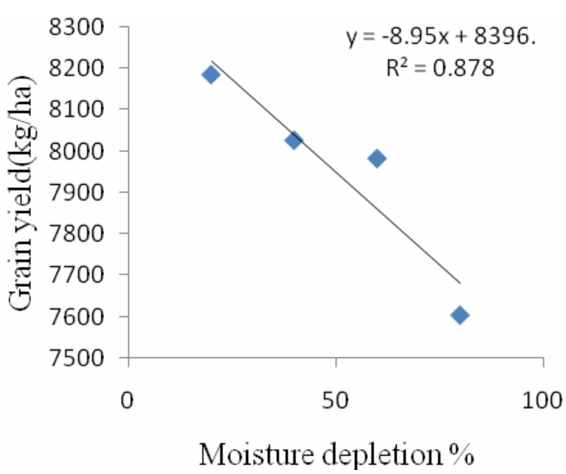

Fig. 1. Corn grain yield response to different levels of moisture depletion.

The highest dry matter yield was observed in MD1 (FC 20%) as 16732 kg/ha and the lowest was found in MD4 as 13171 kg/ha (Table 2). Generally, the dry matter production under 20% FC was significantly higher ($p < 0.01$) than those under the other irrigation treatments. The reason for higher dry matter yield in MD1 can be attributed to favorable soil water conditions created in MD1 plots, which enhanced the vegetative development. The highest and lowest biomasses obtained, respectively at 300 kg N/ha (16732 kg/ha) and 150 kg N/ha (13171 kg/ha). However, there was no significant difference between 250 and 300 kg N/ha. Wiebold and Scharf (2006) indicated that nitrogen increased yield of dry matter in corn.

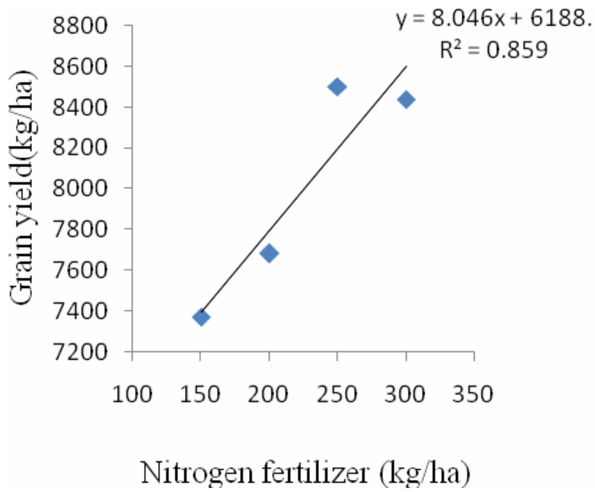

Fig. 2. Corn grain yield response to different levels of nitrogen fertilizer.

Increasing in nitrogen fertilizer levels and moisture depletion increased contribution of dry matter remobilization from stem and leaf to the grain (Table 2). Interaction effect of moisture depletion and nitrogen levels showed that the highest and lowest contribution was observed in MD4 × 300 kg N/ha and MD1 × 150 kg N/ha with average of 6.54 and 3.67%, respectively (Table 2). The extent of stem reserve mobilization during grain filling and the proportion of these reserves in final grain mass depend on cultivar attributes, such as source : sink ratio, and are strongly influenced by prevailing environmental conditions (Hokmalipour and Darbandi 2011).

Drought stress had significant difference between chlorophyll a and b values (Table 1). Table 2 shows that increasing in severity of drought decreased chlorophyll synthesis. So that, the highest values of chlorophyll a and b obtained at MD1, with an average of 3.768 and 2.127 mg/g fresh weight of leaves and the lowest values with an average of 1.341 and 0.108 mg/g in MD4 (Table 2). Results of Kaman *et al.* (2011) were similar with the study.

Increasing in nitrogen application increased chlorophyll a and b values. The highest values of chlorophyll a and b were related to 300 kg N/ha treatment, while the lowest values belonged to the application of 150 kg N/ha (Table 2). Sakinejad, (2002) and Karimpour *et al.* (2014) reported that, severe reduction in soil moisture limits nitrogen uptake and this would be resulted to decrease in chlorophyll a and b values. (Rashidi 2004, Esmaeilian and Ghalavi 2014) reported that nitrogen limitation reduce the positive effects of increased nitrogen fertilizer when soil moisture is lost.

Table 2. Mean values of the traits as affected by moisture depletion and nitrogen fertilizer.

Treatment		Grain yield (kg/ha)	Biologic yield (kg/ha)	PLDMR † (%)	PSDMR‡ (%)	Chl. a (mg/g/Fw)	Chl. b (mg/g/Fw)	Carotenoid (mg/g/Fw)
Moisture depletion (MD)	Nitrogen fertilizer (N)							
MD1	150	7556.1 b	13801 c	0.66 c	3.67 c	1.630 d	0.985 c	1.252 b
	200	8171.3 ab	14110 b	0.90 b	3.60 c	2.483 c	1.550 b	1.288 b
	250	8700.8 a	16732 a	2.93 a	4.47 b	3.480 b	1.642 b	1.391 b
	300	8877.5 a	15152 ab	3.09 a	5.56 a	3.768 a	2.127 a	2.100 a
MD2	150	7229.2 b	13441 c	1.24 c	3.79 b	1.438 d	0.840 c	1.117 b
	200	8055.6 ab	14332 b	1.81 b	4.00 a	2.457 c	1.480 b	1.205 b
	250	8410.2 a	15952 a	1.84 b	4.01 a	3.480 b	1.620 b	1.370 b
	300	8432.2 a	16200 a	3.97 a	4.04 a	3.706 a	1.911 a	1.664 a
MD3	150	6914.1 c	14332 a	1.91 c	4.14 c	1.347 c	0.266 c	1.105 b
	200	7521.3 b	13831 b	1.92 c	4.59 b	2.425 b	1.410 b	1.204 b
	250	8330.2 a	14460 a	2.90 b	4.76 b	3.444 a	1.443 b	1.33 b
	300	7521.3 b	13832 b	3.96 a	5.30 a	3.605 a	1.702 a	1.511 a
MD4	150	6533.2 b	13171 b	2.13 c	4.16 c	1.341 c	0.108 c	0.902 b
	200	7033 ab	13841 ab	2.07 c	4.75 b	2.405 b	1.250 b	1.071 b
	250	7395.6 a	14072 a	2.72 b	4.76 b	3.30 a	1.487 a	1.220 a
	300	7428.7 a	14101 a	4.02 a	6.54 a	3.44 a	1.487 a	1.377 a

† = Partitioning of leaf dry matter remobilization, ‡ = Partitioning of stem dry matter remobilization. Same letters in columns are not significantly different at $p \leq 0.05$.

Results also showed that the effects of different irrigation levels and moisture depletion were not significant on carotenoid content (Table 1). But, increasing nitrogen levels increased average of carotenoid content (Table 2). The interaction between moisture depletion and nitrogen was significant difference ($p < 0.01$) (Table 1). The highest and lowest values of carotenoid obtained at MD1 × N4 and MD4 × N1 treatments, respectively, with an average of 2.100 and 0.902 mg/g fresh weight of leaves (Table 2).

References

Amanullah K, Marwat B, Shah P, Maula N and Arifullah S 2009. Nitrogen levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. Pak. J. Bot. **41**: 761-768.

Boz B 2001. Validation of the Ceres-Maize Growth Model under Cukurova Region Conditions. Department of Agricultural Structures and Irrigation, Institute of Natural and Applied Sciences, Cukurova University, M.Sc. Thesis, 59, Adana.

Bozkurt Y, Yazar A, Gencel B and Sezen SM 2006. Optimum lateral spacing for drip-irrigated corn in the Mediterranean Region of Turkey. Agric Water Manag **85**:113-120

Dhopte AM and Manuel LM 2002. Principles and techniques for plant scientists. 1st Ed., Updesh Purohit for Agrobios (India), Odhpur, and ISBN: 81-7754-116-1, pp. 373.

Ercoli L, Lulli L, Mariotti M, Mosani A and Arduini I 2008. Post-anthesis dry matter and nitrogen dynamics in durum wheat as affected by nitrogen supply and soil water availability. Eur. J. Agron. **28**: 138-147.

Esmaeilian Y and Ghalavi M 2014. Agronomic responses of maize hybrids to water and nitrogen management under diverse climatic conditions of Iran. Int. J. Biosci.. **4**: 27-42.

Fatemi R, Kahraryan B, Ghanbary A and Valizadeh M 2006. The evaluation of different irrigation regimes and water requirement on yield and yield components of corn. J. Agric. Sci. **12**: 133-141.

He P, Zhou W, Jin JY 2004. Carbon and nitrogen metabolism related to grain formation in two different senescent types of maize. J. Plant. Nutri. **27**: 295-311.

Hokmalipour S and Darbandi M 2011. Investigation of nitrogen fertilizer levels on dry matter remobilization of some varieties of corn (*Zea mays* L.). World Applied Sci. J. **12**: 862-870.

Islam MR, Garcia SC and Horadagoda A 2012. Effects of irrigation and rates and timing of nitrogen fertilizer on dry matter yield, proportions of plant fractions of maize and nutritive value and in vitro gas production characteristics of whole crop maize silage. Animal Feed Sci. Tech. **172**: 125-135.

Kaman H, Kirdab C and Sesverenc S 2011. Genotypic differences of maize in grain yield response to deficit irrigation. Agric. Water Manage. **98**: 801-807.

Karimpour M, Siosemardeh A, Fateh H, Badakhshan H and Gholamreza H 2013. Effects of nitrogen fertilizer on yield and some physiological characteristics on two drought resistance and susceptible wheat (*Tritticum aestivum* L.) cultivars in response to water stress. Int. J. Farming Applied Sci. **2**: 311-324.

Khalili M, Moghaddam M, Kazemi Arbat H, Shakiba MR, Kanooni H and Choukan R 2010. Effect of drought stress on different corn genotypes. J. Agric. Sci. **2**: 67-84

Kirda C, Topcu S, Kaman H, Ulger AC, Yazici A, Cetin M and Derici MR 2005. Grain yield response and N-fertiliser recovery of maize under deficit irrigation. Field Crop. Res. **93**:132–141.

Lauer J 2003. What happens within the corn plant when drought occurs? Corn Agron. **10**: 153-155.

Li SX 2007. Dry land Agriculture in China. pp. 42-444. Science Press, Beijing.

Mohammadi H, Soleymani A and Shams M 2012. Evaluation of drought stress effects on yield components and seed yield of three maize cultivars (*Zea mays* L.) in Isfahan region. Int. J. Agric. Crop Sci. **4**: 1436-1439.

Rashidi SH 2004. Effect of drought stress at different growth stages and different levels of nitrogen fertilizer on yield and yield components in maize TC647 climate of Khuzestan. MS Thesis in Agronomy. Agricultural Sciences and Natural Resources of Khuzestan. pp. 151.

Sakinejad T 2002. Water stress effect on the uptake process of nitrogen, phosphorus, potassium and sodium in different periods of growth, according to morphological and physiological characteristics of corn in Ahvaz climate. Ph.D. thesis crop physiology. Islamic Azad University, Science and Research Unit of Ahwaz. pp. 288.

SAS Institute, Inc. 2004. SAS/STAT 9.1 User's guide. SAS Institute Inc., Cary, NC.

Wiebold B and Scharf P 2006. Potassium deficiency symptoms in drought stressed crops, plant stress resistance and the impact of potassium application south China. Agron. J. **98**: 1354-1359.

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